Deep neural networks for the evaluation and design of photonic devices

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Abstract

The data-science revolution is poised to transform the way photonic systems are simulated and designed. Photonic systems are, in many ways, an ideal substrate for machine learning: the objective of much of computational electromagnetics is the capture of nonlinear relationships in high-dimensional spaces, which is the core strength of neural networks. Additionally, the mainstream availability of Maxwell solvers makes the training and evaluation of neural networks broadly accessible and tailorable to specific problems. In this Review, we show how deep neural networks, configured as discriminative networks, can learn from training sets and operate as high-speed surrogate electromagnetic solvers. We also examine how deep generative networks can learn geometric features in device distributions and even be configured to serve as robust global optimizers. Fundamental data-science concepts framed within the context of photonics are also discussed, including the network-training process, delineation of different network classes and architectures, and dimensionality reduction. Neural networks can capture nonlinear relationships in high-dimensional spaces and are powerful tools for photonic-system modelling. This Review discusses how deep neural networks can serve as surrogate electromagnetic solvers, inverse modelling tools and global device optimizers.